

Use of Artificial Shelters (“Casitas”) as an Alternative Tool for Stock Evaluation and Management of Caribbean Spiny Lobsters in Banco Chinchorro (México)

El Uso de Refugios Artificiales (“Casitas”) como una Herramienta Alternativa para el Manejo y la Evaluación del Stock de la Langosta Espinosa del Caribe en el Banco Chinchorro (México)

Utilisation des Abris Artificiels (Casitas) comme un Outil Alternatif pour Valuation de Gestion et de Stock de Langoustes des Caraïbes dans la Banco Chinchorro (Mexique)

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ABSTRACT

Large reproductive adults of Caribbean spiny lobsters (*Panulirus argus*) are being depleted in lobster populations throughout the Mesoamerican Reef. In Banco Chinchorro (BC, Mexico), an oceanic coralline atoll and Biosphere Reserve where fishing for *P. argus* is allowed, fishing pressure on reproductive adults is also high. Although catch rates have remained relatively stable for the last decade, catch rates were previously much higher and current lobster production is low. An inter-institutional steering committee was established to propose a series of actions in order to create alternative fishing practices and new management ideas, as a strategy for repopulating and analyzing local lobster stock of *P. argus* in BC. Based on knowledge obtained in previous studies carried out elsewhere in Mexico and in other Latin American countries, preventive measures for reducing fishing effort and pressure on reproductive adults in BC include a controlled deployment of “casitas” (large artificial shelters) as an innovative tool for local stock assessment that will provide useful data to examine juvenile growth rates, local migrations, and the potential for repopulation. Responsible use of casitas within a well regulated BR, incorporated in a cooperative based socio-economic scheme, is hereby perceived as a useful initiative for defining future management action plans in this area.

KEY WORDS: *Panulirus argus*, artificial shelters, biosphere reserve, stock assessment, management

INTRODUCTION

Caribbean spiny lobsters are a valuable fishing resource throughout the wider Caribbean region. Along most of the Mesoamerican Reef, located on the western Caribbean basin, large reproductive adults of Caribbean spiny lobsters (*P. argus*) are being increasingly depleted (Ehrhardt et al. 2010). Because egg production increases non-linearly with female size (Fonseca-Larios and Briones-Fourzán 1998), and large females require sperm from large males to fertilize each clutch of eggs (MacDiarmid and Butler 1999), removal of large reproductive adults may impact the production of larvae (Bertelsen and Matthews 2001). In Banco Chinchorro (BC), an oceanic atoll located off the southeastern coast of the Yucatan peninsula (Mexico), the fishery for *P. argus* has historically targeted large reproductive adults (Sosa-Cordero 2003, Lozano-Álvarez 1994). In this paper we describe a new research program conducted in BC as a joint effort promoted by an inter-institutional steering committee established to propose a series of actions in order to implement alternative fishing practices for *Panulirus argus* and new management ideas for all stakeholders involved with the fisheries. This committee is composed of several fishing cooperatives, government agencies, universities and research institutions, and NGOs. The aim of this study was to put together a proposal to assist the fishing cooperatives in improving management of the lobster resource through the deployment of “casitas” as a strategy for increasing lobster biomass in areas poor in natural shelters for lobsters.

Casitas are large artificial shelters that harbor the full size range of lobsters (Lozano-Álvarez et al. 1991, Sosa-Cordero et al. 2008). Casitas were first used in Cuba (Baisre 2000, Cruz and Phillips 2000), and then in Mexico (Briones-Fourzán et al. 2000) and the Bahamas (Deleveaux and Bethel 2002) to harvest lobsters. In Mexico, casitas are extensively used in two large bays (Bahía de la Ascensión and Bahía Espíritu Santo) that form part of the Sian Ka’an Biosphere Reserve, which is located in the central portion of the eastern coast of the Yucatan Peninsula. The fishing cooperatives that operate in these bays have devised an organizational scheme that has rendered the fishery remarkably sustainable (Lozano-Álvarez et al. 1991, Briones-Fourzán et al. 2000, Defeo and Castilla 2005, Sosa-Cordero et al. 2008). This scheme consists of the partitioning of the fishing areas in the bays into parcels (“campos”) allotted to individual fishers. A fisher does not own his campo (as this is forbidden by law) but is free to deploy within his campo as many casitas as he is willing to invest in, and hence he owns the casitas. On average, there are 3.3 casitas/ha in individual campos with distances between casitas varying from 25 m to over 50 m (Lozano-Álvarez et al. 2003). Using diving masks and snorkels, the fishers survey the casitas and extract the lobsters with hand nets. Federal regulations include a minimum legal size of 135 mm abdominal length (~74 mm

carapace length on average), a four month closed season (March 1 to June 30), and a prohibition on capturing ovigerous females as well as on using gaffs or hooks to extract lobsters. Internal regulations of the cooperative forbid fishing in someone else's campo, as well as the use of SCUBA or hookah diving (Sosa-Cordero et al. 2008).

The casitas/campos system has not been previously implemented in BC. However, in a study conducted between 2005 and 2007, 56 experimental casitas were deployed in the atoll lagoon of BC to study growth, movements, and prevalence of *P. argus* lobsters with the PaV1 disease (Ramírez-Estévez et al. 2010). In total, 1060 lobsters ≥ 20 mm carapace length (CL) were marked and 404 (38%) were recaptured. Distance moved by individuals (measured over a straight line) varied between 11 m and 4.2 km, with some extreme movements of 16, 19, and 37 km. This is the only documented information on the previous use of casitas in BC.

The present initiative represents an excellent opportunity to obtain scientific data to analyze the local lobster stock within BC where no operations of this magnitude have been conducted before. Data on lobster growth, natural and fishing mortalities, movements, and abundance will be obtained in order to support a more informed decision-making adaptive management scheme for the cooperatives and the managers of this Biosphere Reserve. Based on a small-scale pilot study conducted in 2009 – 2010, a larger project ("main project") was designed to deploy 900 casitas to enhance the lobster population in BC. A financial projection was also developed based on previous knowledge on the average number of lobsters (kg) harvested per casita obtained in studies from Puerto Morelos and from the two bays located within the Sian Ka'an Biosphere Reserve (Lozano-Álvarez 1992, Lozano-Álvarez et al. 1993; Briones-Fourzán et al. 2000, 2007, Briones-Fourzán and Lozano-Álvarez 2001). Based on these estimates it was calculated that the casitas will also improve the economic revenue of the fishers.

Additionally, we present information on the main areas where campos will be established and casitas will be deployed, the number of casitas to be deployed, the amount of lobsters likely to be found in casitas, and discuss how the use of casitas will likely affect the effort and rate at which lobsters are harvested in this area. It is expected that results will help define future management action plans in BC and other Mesoamerican Reef areas.

Description of Banco Chinchorro

Banco Chinchorro is located off the southeast coast of the Yucatan Peninsula, Mexico, near the border with Belize, and was declared a Biosphere Reserve in 1996 (López and Consejo 1986, INE-SEMARNAP 2000) (Figure 1). It is an oval-shaped atoll-like reef with a surface area of 144,360 ha, centered at 18° 35' N and 87° 21' W. The longest axis measures 43 km and the shortest axis is 18 km. It is separated from the coast by a distance of 30.8 km

from the nearest port (Mahahual) and by a channel ~1000 m in depth (INE-SEMARNAP 2000; González et al. 2003). Banco Chinchorro is a complex system of coral patches and ridges encompassing a reef lagoon. It has up to 14% hard coral coverage in some sites, significantly higher than the average of 8% estimated for the Caribbean Sea (Chávez et al. 1985, Jordán-Dahlgren and Martín-Chávez 1987). The distance from the coast and its status as a protected area have minimized the impact of coastal development on the ecosystems.

The Lobster Fishery at Banco Chinchorro

The fishery for *P. argus* has historically been the main economic activity for the communities that make use of BC. Fishing for lobsters is restricted to licensed fishing cooperatives and lobster landings have stabilized during the last decade (Sosa-Cordero 2003, Ley-Cooper 2006, Chávez and Ley-Cooper 2007, Ley-Cooper and Chávez 2010), with catches varying around 25 t (lobster tails) (Figure 2) (CONAPESCA 2009). These catches have been achieved without an apparent increase in effort, contrary to patterns observed in other Caribbean fisheries (FAO 2001, de León et al. 2005). Local environmental factors at BC, patterns of recruitment, and growth of lobsters may have helped to sustain the current stock sizes (Lozano-Álvarez 1994, Sosa-Cordero 2003, Ley-Cooper 2006, Chavez and Ley-Cooper 2007). However, the specific biological characteristics of the population must be systematically monitored, revised, and analyzed in a scientific manner in order to assess sustainability of the fishery (Thomson and Caputi 2005, Wright et al. 2006).

The lobster fishers are organized into cooperatives that obtain a 20 year fishing concession with annual renewals. In BC, three cooperatives have rights to fish for lobsters. Cooperatives must comply with the current fishing regulations which include a closed season from 1 March to 30 June, a minimum size of 135 mm tail length (~74 mm carapace length, CL), and a prohibition on capturing egg-bearing females. Skin diving without alternative air source equipment is the only method for fishing lobsters (López and Consejo 1986, Lozano-Álvarez et al. 1993, Sosa-Cordero et al. 1998). This limits the catch of the lobsters to depths < 20 m (Lozano-Álvarez et al. 1991, Sosa-Cordero 2003, Ley-Cooper 2006, Ley-Cooper and Chávez 2010).

Some of the benefits of introducing casitas in BC are:

- i) Casitas increase survival of lobsters because they allow for cohabitation of small juveniles, which are more vulnerable to predation, with larger conspecifics that have greater individual and collective defensive abilities (Eggleston and Lipcius 1992, Briones-Fourzán et al. 2007),
- ii) Casitas allow lobsters to exploit the available food resources in a more efficient way, reducing their time of exposure to predators (Lozano-Álvarez 1995),

- iii) Because casitas are deployed far from the coral reefs, their use reduces impact of fishers on the reefs and on the large reproductive adults that dwell in these habitats, and
- iv) Casitas allow for selectivity in size and maturity of lobsters, which can be harvested (and sold) alive, adding economic value to the product (López and Consejo 1986, Lozano-Álvarez et al. 1993, Sosa-Cordero et al. 1998, Ley-Cooper and Chávez 2009). The best way of introducing casitas would be in a campos system, which allows for semi-ownership of casitas and self-surveillance and could improve vigilance by park rangers and cooperatives.

MATERIALS AND METHODS

Deployment of Casitas in BC

For the past few years, efforts to discourage the sale of lobster tails and encourage the fishers to catch live lobsters in BC have been made by federal agencies and NGOs. The

most recent campaign was under the theme “catch the lobsters alive, it’s worth more” which promoted several aspects:

- i) The use of snares and hand nets to catch lobsters (instead of using gaffs),
- ii) A fishers exchange program where cooperatives from BC were trained by other fishers from SK to handle live lobsters on boats, and
- iii) The construction and deployment of casitas constructed of recycled wood.

As part of these efforts, a pilot study using 70 casitas was conducted from 2009 - 2010. Most of these casitas were deployed in a fishing area around Cayo Centro (Figure 3), where a research station is located), whereas some casitas were deployed in a no-take zone to provide an experimental area for tagging and recapture of lobsters in the absence of fishing, thereby providing a “control site”. The casitas were deployed in a 50 x 50 m grid, as this design is optimum for the foraging and survival of lobsters (Briones-Fourzán and Lozano-Álvarez 2001, Zapata-Araujo et al. 2007). Casitas were left to soak for at least one month before being checked. In order to begin this operation fishers had to select a campo, and campos were assigned for exclusive rights for individual boats, in order to install and check their casitas throughout the season, where tagging of all undersized and egg bearing lobsters was conducted.

The three fishing cooperatives have collaborated with the data collection. Other activities, including processing historical data, are being conducted in coordination with the cooperatives, technicians, park rangers, NGOs, and volunteers, in order to ensure continuity on gathering biological data such as CL, weight, sex, and sexual maturity to be registered in logbooks. All participants have been duly trained. Parallel to this, effort data (individual boat catch per day, and weekly, monthly and yearly landings) is being gathered. In order to determine CPUE, the number of fishers, casitas and sites visited per day are

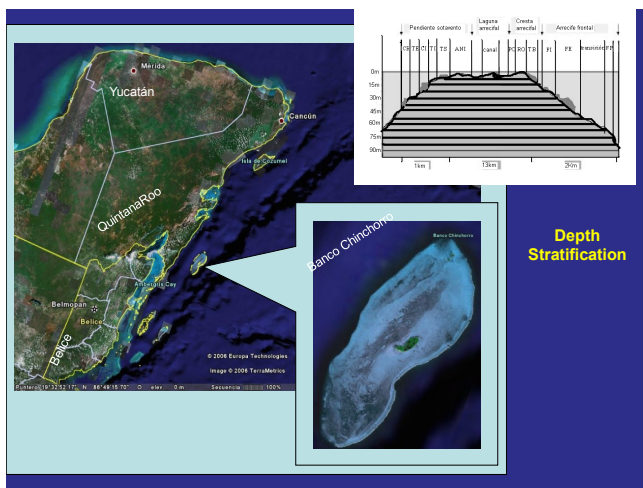


Figure 1. Location of study area (Banco Chinchorro)

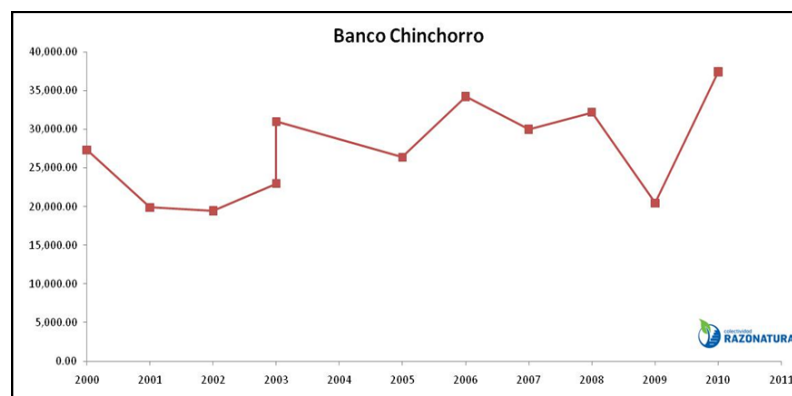


Figure 2. Total catches (Kg) of the *Panulirus argus* lobster fishery in Banco Chinchorro Biosphere Reserve 2000 - 2010. Includes data from all the three Cooperatives which are entitled to exclusive concessions rights over the fishery.

also being recorded. Data derived from logbooks is being complemented with information provided by the cooperatives' mother ships at the reception sites, and with government fisheries statistics. These data will be subjected to change-in-ratio techniques and used to estimate catchability and an index of lobster removal, all of which are indirect methods of estimating population sizes useful for management (Melville-Smith et al. 2006, Pollock et al. 1985).

The main project, which commenced in 2010, essentially follows the same protocol used in the pilot study. We are now under the process of installing up to 900 casitas. A stimulus for the main project was the financial projection, which yielded an estimate of at least 3 kg of lobsters per casita, potentially providing a significant increase in economic returns to the fishers. If the criteria of analysis for a preliminary projection are based on accurate economic estimates, and the 900 casitas to be deployed work as expected, we could make a conservative estimate and expect an average harvest rate of at least 3 kg (whole weight) per casita per season. An assumption could be made that these casitas would at least produce 2,700 kg per season. Based on the catch obtained during 2009 by the Cooperative "Banco Chinchorro", catch would therefore increase by 5.6% (Table 1). Considering a dock price of \$380 MXP per kg of lobster tail and of \$200 MXP per kg of live lobster, this would mean an income increase during the first year of casita operation of \$342,000 MXP (5.6%) if only lobster tails were commercialized, and \$540,000 MXP pesos (8.8%) if lobsters were sold live, which is one of the recommendations of the steering committee.

Table 1. Projection of total catches for the Cooperative "Banco Chinchorro" based on the assumption that the conditions of relative stability in the yearly catches observed for the last decade are maintained and that catches increase at a 5.6% rate per year.

Year	Tail weight (kg)	Whole weight (kg)
2009	16,070.0	48,210.0
2010	16,969.9	50,909.9
2011	17,420.2	53,460.7
2012	18,395.7	55,187.2

Tagging and Recapture Program for BC

The main project is being complemented by a tagging campaign to evaluate the relationship between the stock subject to fishing (at depths ≤ 20 m) and the stock that escapes fishing (> 20 m in depth), and to estimate fishing mortality. Further details are provided below. The tagging protocol in both the pilot study and the main project in BC was similar to a tagging protocol implemented in Bahía del Espíritu Santo since 2009 (Unpublished data). Briefly, lobsters are measured (CL, mm), sexed, examined for sexual maturity and missing limbs, and tagged with Australian "Hallprint" T bar tags applied ventrally (Figure

4). Once a lobster has been measured and tagged with the least exposure to sun and outside the water it is immediately placed back into the water and released under the casita, whose GPS position is recorded.

One of the major knowledge gaps in assessing the total stock of the BC fishery is the relationship between the abundance of lobsters in shallow (≤ 20 m) and deeper (> 20 m) habitats. The proportion of the population in these habitats is fundamental for understanding the fishery, and is the main incentive for tagging adult lobsters in the deeper areas. These lobsters are caught beyond the reach of the skin-diving fishery (i.e. > 20 m) and released as near as possible to their point of capture. These tagging activities will be conducted at locations in the north, south, and east parts on BC.

The combination of casita and skin-diver based surveys will provide different yet complementary results that will allow a more comprehensive examination of abundance, size distribution and migration patterns across all size classes and in most areas. This research will also allow an assessment of movements, time at large, and growth of recaptured lobsters throughout the year. The tagging programs will be advertised widely and a reward program will be introduced to encourage tag returns.

Progress to Date

The construction of casitas commenced in June 2010. However, the process of designing and constructing casitas with sustainably certified recycled wood from a nearby forestry community has taken more time than expected. Up to September 2011, approximately 400 casitas have been deployed in the fishing areas where campos are being established by fishers from the cooperatives and approximately 40 casitas have been installed in the no take areas. It is expected that 900 casitas will be deployed by December 2011. The locations of the deployed casitas are shown in Figure 3.

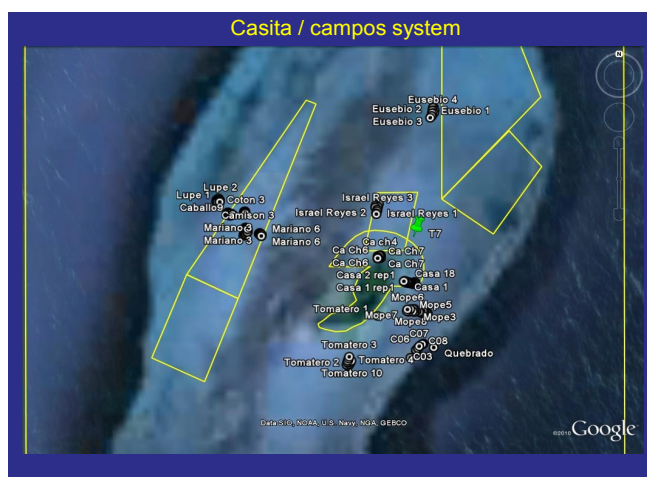


Figure 3. Location of proposed campos and no-take zones where casitas are being deployed in Banco Chinchorro

Up to October 2011, we had tagged 437 lobsters (32.0–152.3 mm CL) both from casitas and the deep reef habitats (52% males and 48 % females). Out of these lobsters, 22.6% were of sublegal sizes and 77.4% of legal sizes. The largest lobsters, ranging from 140 mm to 152.3 mm CL, were caught on the deep habitats over the east side of BC. Since most of the lobsters tagged in casitas were < 78 mm CL (i.e., sublegal), and most of the larger lobsters were tagged in the deep habitats, out of reach of free diving, the fishers have reported few recaptures. Most recaptures have been obtained in the no-take area by the research staff, and many of these lobsters had been at large for longer than a week.

DISCUSSION

Casitas are mostly used to harvest lobsters for commercial purposes. However, in this study they are also being used as a tool for local stock assessment, i.e., to provide useful data to examine juvenile growth rates, local movements, and as a potential instrument for:

- i) Enhancing the local stock through an increase in survival,
- ii) Reducing fishing effort on reproductive adults, and
- iii) Mitigating impact on coral reef habitats.

The potential of casitas to enhance the lobster stock in BC is yet to be analyzed, and this project presents an opportunity for it. Previous studies have shown why casitas deployed in no-take areas could help understand this process. Predation is a main cause of mortality of young juvenile lobsters (Butler et al. 1997) because defense strategies such as the use of their spiny antennae to fend off predators (Briones-Fourzán et al. 2006) are not very efficient in small juveniles (Childress et al. 1997). However, coordinated group defense within a refuge is a social behavior of *P. argus* and has been documented as an efficient counter attack against predators (Herrnkind et al. 2001, Briones-Fourzán et al. 2006), and to considerably diminish mortality per capita (Eggleston and Lipcius 1992,

Briones-Fourzán et al. 2007). In extensive sea-grass areas where natural refuge is scarce and heterogeneously dispersed, as is the case in the atoll lagoon of BC, casitas will be able to serve as refuge and to increase lobster gregariousness (Briones-Fourzán and Lozano-Álvarez 2001).

Since *P. argus* lobsters undergo ontogenetic habitat shifts, lobsters will eventually abandon the “casitas” as they grow, but other smaller lobsters will recruit into the casitas, potentially resulting in a production increase (Arce et al. 1997, Briones-Fourzán and Lozano-Álvarez 2001, Sosa-Cordero et al. 1998). Based on the success of the casita-based fishery in the bays of Sian Ka’an (Lozano-Álvarez et al. 1991, Arceo et al. 1997, Sosa-Cordero et al. 1999, 2008), a responsible use of casitas within a well regulated and managed fishery seems to be a good option for the cooperatives in BC. Open-access fisheries which occur in other areas of the Caribbean are progressively leading to potential collapses, a typical example of a “tragedy of the commons” (Hardin 1968). This contrasts with the management system in BC where governance and enforcement of the regulations by the cooperatives exists. The casitas/campos system established in the bays of Sian Ka’an, largely self-regulated by the cooperatives, constitute a unique lobster harvesting technique, since it virtually divides the sea floor into a series of parcels given out as territorial ownership to individuals for a better management of the resources within them. Based on knowledge obtained in previous studies carried out in SK and in other Latin American countries such as Cuba, preventive measures for reducing fishing effort and pressure on reproductive adults in BC could include a controlled deployment of casitas.

As mentioned above, biophysical factors related to the ecosystem (oceanographic properties such as currents, temperatures) and other aspects related to the general biology of the species, are all unknown variables to be considered in the general Bio-economics of the equation which could describe the effects of casita deployment in BC. However, the most important variables wherein measurable changes could take place with the use of casitas are: average age of first capture, changes in fishing effort and CPUE, (Ley-Cooper and Chávez 2010), juvenile survival rates (Briones-Fourzán and Lozano-Álvarez 2001), proportions of egg bearing females present in casitas, and the effects of casitas on large reproductive adults (Sosa-Cordero et al. 1998). Therefore, this initiative represents a unique opportunity to study the effects of an increase of artificial refuge in an oceanic atoll where casitas have never been used for commercial purposes (Briones-Fourzán and Lozano-Álvarez 2001, Briones-Fourzán et al. 2007).



Figure 4. Tagged lobster (*Panulirus argus*) at Banco Chinchorro.

Expected Results from These Studies

This study is yet to be completed, so there is no comprehensive analysis of the data at this stage, but we expect that the study will provide information to help stakeholders define future management plans for the lobster fishery in BC. Previous research has suggested that fishing mortality and effort based on current fishing practices should not be increased in BC (González-Cano et al. 2000a, 2000b, Sosa-Cordero 2003, Ley-Cooper 2006). This project intends to trade-off fishing effort on the large reproductive adults that dwell in coral reef habitats for fishing effort on lobsters using casitas. This trade-off will occur gradually. For example, currently all of the members of one of the three fishing cooperatives that operate in BC (“Langosteros del Caribe”) and about 30% of the members of another cooperative (“Pescadores de Banco Chinchorro”) have abandoned the use of the gaff and now use lobster snares. Therefore, it is possible that all legal lobsters harvested from casitas will eventually be sold live/whole.

Further research on population dynamics, age structure, CPUE, movements, survival rates, and economic impacts will be carried out to evaluate the effects of the casitas on the lobster stock, recruitment, and survival. Also, a more comprehensive bio-economic analysis, including stock relationship will be required when the study is finished. Results need to be revised at the end of the study to confirm what the actual catch rates per casita were achieved, and analyze its effects on fishing effort.

Knowledge obtained during this study will set the basis to provide a better understanding of the long term dynamics of spiny lobster fisheries where casitas may be used in the Caribbean, and hopefully provide evidence for recommendations to improve the livelihoods of the artisanal fishers in BC. The study will produce a series of recommendations for improving management policies and fishing practices. Fishers should be shown that it is more profitable in the long term to abandon the catch of large adults, which will contribute to the sustainability of this important species. This could be supported by new commercial strategies for adding value to maximize socioeconomic benefits without increasing fishing effort, which in turn could improve local governance and sustainability within a community-based capacity-building framework.

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